Bridge Analysis Report

EXECUTIVE SUMMARY

Introduction

The Bridge Analysis Report was completed to identify and recommend feasible overhead structure types for use in the Reno Railroad Corridor. The overhead structures recommended in this report are required to meet specific criteria as defined in the analysis section. Determination of feasibility was accomplished through an analysis of each proposed structure type.

The proposed overhead structure types for the local street crossings over the depressed rail alignment are summarized below:

1. <u>Through Girder</u>

   Although through girder sections are commonly used for railroad structures, they are uncommon for highway bridges. Exterior girders, located above and outside the roadway deck, distinguish this structure from the other structure types. Due to these girders, the overall structure width of a through girder bridge is wider than traditional highway structures carrying an equivalent number of traffic lanes. These exterior girders also present an obstruction to traffic at or near intersections, requiring additional detailing of crash cushions to address safety concerns. Furthermore, the soffit slab is relatively thick and oftentimes requires post-tensioning to span between girders.

2. <u>Precast/Prestressed I-Girder</u>

   Constructed of premanufactured beams resting on bearing pads at the abutments subsequently supporting an integrated reinforced concrete deck, precast/prestressed I-girder bridges are commonly utilized for medium span solutions. The deck integration employs a positive connection between cast-in-place decks and the top flange of the beams through steel reinforcement. Using this technique, the deck can be shaped to specification.

   Precast I girders are typically applicable to spans up to about 90 feet where erection of conventional falsework is not feasible or desirable. Such beams are particularly economical if conditions are favorable to mass fabrication or subject to time constraints.

   The Federal Highway Administration and state highway departments have developed standard designs for precast/prestressed girder structures.

3. <u>Cast-In-Place Reinforced Concrete Box Girder</u>

   A box girder structure consists of open cells bounded by girders (exterior and interior), a deck (above), and a soffit (below). Extending beyond the open cells, the deck surface creates overhangs. Box girder structures are substituted for steel structures frequently when steel prices relative to reinforced concrete are high. In addition, the geometric properties of box girder structures resist larger torsional forces. Traditionally reinforced, concrete box girder superstructures are typically used for span lengths of 50- to 120-feet. Preliminary determination of the total structural depth is accomplished with a depth-to-span ratio. In the case of box girder structures for highway loading, the commonly accepted design ratio yields a structure depth that is approximately 6% of the span length.

Adding to the benefits of torsional resistance and lower construction costs, box girders are considered to be one of the most aesthetic bridge types available due to their smooth lines and closed structure.

Concrete box girder structures are constructed in phases. These phases include two concrete placement procedures, namely stem/soffit and deck pours. These independent pours, coupled with the intricate reinforcement detailing, lengthen the construction time required for completion of these structures.

4. Steel I-Girder

Steel I-Girder structures consist of rolled steel or built-up plate I-girders overlain with a cast-in-place concrete deck, all resting on bearing pads at the abutments. The deck slab is formed around shear studs welded to the flanges of the I-beams. Common span ranges for steel girder bridges are 60- to 300-feet. Steel girders are typically spaced at 7'-6" to 10'-6" apart and the recommended span to depth ratio, like reinforced concrete box girder bridges, provides a structure depth of approximately 6% of the span length.

5. Post-Tensioned Reinforced Concrete Slab

Slab structures are typically the most cost-effective structural solution for spans up to 40 feet. However, for longer spans, the economic benefits reduce dramatically. Use of slabs over 40 feet in length generally requires post-tensioning. Oftentimes, slabs are cast with voids running longitudinally, thereby reducing the self-weight of the structure. However, when voided slabs are employed, the structure depth must be increased to carry the same load. For larger spans, deeper sections using higher concrete strengths are expected. There is a delicate balance between performance and cost-effectiveness with voided slabs.

Post-tensioned concrete slabs are typically applicable to span lengths up to 65-feet. Using the industry standard depth to span ratio (0.030), preliminary calculations indicate the required structure depth to be approximately 1'-9". However, with the potentially large added dead loads within the Central Reno vicinity, concrete strengths in excess of 10,000 psi were required to maintain the standard depth-to-span ratio. To reduce the required concrete strength to acceptable limits (6,000 psi or less), the depth of the slab must be increased to approximately 2'-4". The difference in cost between a 2'-4" solid slab with post-tensioning and a 3' deep box girder structure is considerable. Since the depth of 2'-4" and the required compressive strength of concrete are beyond practical and economic limits, the post-tensioned concrete slab was eliminated as a viable structure type.

6. Precast/Prestressed Bulb Tee

Precast/prestressed concrete bulb tee beams have been used successfully for highway structures since the 1970's. The bulb tee section is similar to an I-girder with thicker and wider flanges. Oftentimes, use of bulb tees eliminates the need for a deck to be installed.

Their use is typically required when cast-in-place alternatives are infeasible or undesirable for medium length spans. Bulb tee beam sizes and details have been standardized by American Association of Highway and Transportation Officials (AASHTO) and Precast/Prestressed Concrete Institute (PCI).

A typical bridge section consists of a series of precast/prestressed bulb tee beams arranged parallel to one-another and placed contiguously. After placement, the adjacent beams are attached to one-another by grouting and/or welding methods. Precast bulb tee beams are readily available in 3 standard sizes that allow the structures to meet the clearance requirements of the Reno Railroad Corridor project. A combination of these standard beam sizes can be utilized to meet width requirements of various structures. When completed, these structures appear similar to facilities constructed of precast/prestressed I-girders.

7. Precast/Prestressed Box Beam

   Precast/prestressed concrete box beams have been used successfully since the mid-1950's. Their use is typically stipulated by the lack of feasibility for cast-in-place alternatives that require higher torsional resistance and faster construction times than open girder options. Box beam sizes and details have been standardized by AASHTO-PCI.

   A typical bridge section consists of a series of precast/prestressed box beams arranged parallel to one-another and placed contiguously. After placement, the adjacent beams are attached to one-another by grouting and/or welding methods.

Analysis

Each of the structure types was analyzed for specific criteria that was of concern for the Reno Railroad Corridor project. The specific criteria used in the analysis of each structure type are listed below:

1. Construction Duration/Sequence

   Structures requiring more than 5 months to construct could impact the progress of the project. Therefore, any structure types requiring more than 5 months should be eliminated from consideration as a viable option. Structure types requiring a shorter construction period were favored.

   The construction sequence of each structure type is discussed in the report, but is not used to eliminate any structures from consideration.

2. Construction Cost

   The three most economical structure types were considered viable. The estimated costs incorporate superstructure steel and concrete, abutment steel and concrete, concrete barriers, railings, excavation, and backfill. The excavation quantities include the cost to excavate for the abutments, but does not include the initial excavation for the overhead cost, which is assumed to be included in the trench construction costs. Overhead structure types with the lowest construction costs were favored.

3. Utility Considerations

Some of the structure types were eliminated from consideration due to there inability to support the utilities that are expected to be carried by the overheads. At a couple of locations 28” diameter pipes must be carried by the superstructure. Structure types without the capacity to carry a 28” diameter pipe were eliminated from the list of plausible structure types.

4. Overall Construction Impacts

Effects to the remainder of the project are 1) Construction noise levels, 2) Traffic control and pedestrian impacts, and 3) Trench excavation. Using the Preferred Alternative (Alt. 5) to be depicted in the *Final Environmental Impact Statement*, overheads will be constructed at each railroad crossing from Keystone Avenue to Evans Avenue.

Although noise from construction vehicles will have an effect on the neighboring community, the difference in noise levels between the structure types is insignificant and was ignored for the purpose of this report.

The construction of any structure type will effect the vehicular and pedestrian traffic in the surrounding area. The placement of required cranes, a large numbers of construction vehicles requiring access to the structure daily, and the nearby area required for staging are examples of some of the items that may effect vehicular and pedestrian traffic in the vicinity of the construction. In addition, the time between the beginning of construction and when vehicular and pedestrian traffic is allowed on the overhead was considered. Structure types that reduced or had limited impacts to the surrounding area were favored.

Construction of the overheads may also impact trench excavation. If the construction time required for each structure is too long then the excavation of the trench may be impacted. Structure types that did not delay the excavation of the trench were given highest consideration.

5. Superstructure Depth

A minimum clearance of 23-feet is required between the top of rail and the bottom of the superstructure for the entire width of the trench. Each structure type fits within a prescribed envelope of 4-feet, with the exception of Keystone Avenue. The 4-foot envelope includes the superstructure depth plus consideration of a 2% cross slope on the local streets. Some of the structure types offer a much smaller structure depth than others, allowing the rail profile grade to be raised later in final design if desired. Raising the rail profile may result in decreased construction costs to the trench and wall systems.

Results

Based on the research of each structure type, Table 1 has been developed to summarize our findings. In the table, each structure type is listed against the selection criteria and marked with a (•) for criteria that is satisfied at all locations and a (X) for criteria that are not satisfied at all locations. Any structure types with a (X) were eliminated as plausible structure types for the Reno Railroad Corridor project.

Location	Critical Screening Criteria			
	Construction Duration/Sequence	Construction Cost	Utility	Superstructure Depth
Through Girder	•	•	X	•
PC/PS I-Girder	•	•	•	•
CIP Box Girder	•	•	•	X
Steel I-Girder	•	X	•	X
PC/PS Bulb Tee	•	X	X	•
PC/PS Box Beam	•	X	X	•

Table 1 Screening Criteria

The above table uses screening criteria to eliminate structure types from consideration. The selection criteria included construction duration/sequence, construction costs, utility consideration, construction impacts/bridge width, and superstructure depth requirements:

Structures requiring more than 5 months to construct could impact the progress of the project. Therefore, any structure types requiring more than 5 months would have been eliminated from consideration. No structure type fell within this category.

The large number of overhead structures involved in the Reno Railroad Corridor project renders overhead construction costs as a major concern. The cost screening criteria was based on a selection of the three structure types with the lowest cost. The steel I-girder ($267/ft^2), PC/PS bulb tee ($201/ft^2) and the PC/PS box beam ($246/ft^2) were the three highest costing options and were eliminated from consideration.

Some structure types were eliminated based on the inability of the structure to carry the necessary utilities at a given location. The through girder, PC/PS bulb tee, and the PC/PS box beam structures that did not have sufficient room to carry the utilities, without impacting the vertical clearance between the structure and the rail, and were eliminated from consideration.

Structure types that did not fit within the allowable vertical depth window were eliminated from consideration. The steel I-girder and the CIP box girder were eliminated from consideration. Both structure types violated the 4’-0” window at Keystone Avenue.

Conclusions

The precast/prestressed I-girder section is applicable to all overcrossings, is the most economical ($188/ft^2), has a reasonable construction time, and has the capacity to carry the expected utilities. Therefore, the precast/prestressed I-girder is the preferred structure type for the Reno Railroad Corridor project. As an alternate structure type, for additional construction costs, the cast-in-place box girder section may be considered for all locations other than Keystone Avenue.